PCB FISH CONTAMINATION IN SWISS RIVERS – TRACING OF POINT SOURCES

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Introduction

In 1972, Switzerland banned the application of PCB (polychlorinated biphenyls) in open systems. Further use in closed systems like transformers and condensers was only possible under an exemption clause which was then repealed in 1983. Since 1986, production, import, and use of PCB are completely banned in Switzerland. Nevertheless, several hundred tons of PCB are still present from older applications such as joint sealants[1], anti corrosion coatings, industrially contaminated locations and disposal sites. From these and other diffuse reservoirs PCB can enter the environment via atmospheric deposition, waste water, and runoff [2]. Due to the ban of PCB and the continuous elimination of PCB containing electrical equipment as well as ongoing improvement of waste water treatment, incineration and recycling processes, PCB levels in the Swiss environment have continuously decreased[3-6].

In 2007, analyses of fish from the river Saane revealed extraordinary high levels of dioxin-like PCB (dl-PCB). Several fish species from this river exceeded by far the maximum level of 8 pg WHO-TEQ/g fresh weight (fw) set by the European Union[7]. A maximum of 97 pg WHO-TEQ/g fw was observed in a single fish sample. The former disposal site of La Pila was identified as the responsible point source for the PCB contamination of the river. La Pila was used as a landfill for domestic and industrial waste from 1952 to 1975. The volume of the landfill covering roughly 2 hectares is approximately 195'000 m^3. Wastes are heterogeneously distributed and can be found up to a depth of 20 meters. The amount of PCB was estimated to be more than 20 tons. Solid samples taken at several spots of the landfill revealed PCB levels of more than 1000 mg/kg[8]. Based on the above mentioned findings and due to increasing political pressure a nationwide survey was initiated by the Federal Office of the Environment (FOEN) with the target to obtain an overview of the PCB contamination of Swiss rivers and lakes. Unknown diffuse and point sources should be detected and identified by the monitoring of fish, water, and sediment. This data shall serve as a basis for immediate actions to protect humans, wildlife and the environment from the exposure to PCB.

Materials and Methods

Samples: Fish and sediment samples were taken by the responsible cantonal authorities, and analyses were carried out by contract laboratories. PCB and polychlorinated dibenzo-*p*-dioxins and dibenzofurans (PCDD/F) were determined in fish, water and sediment.

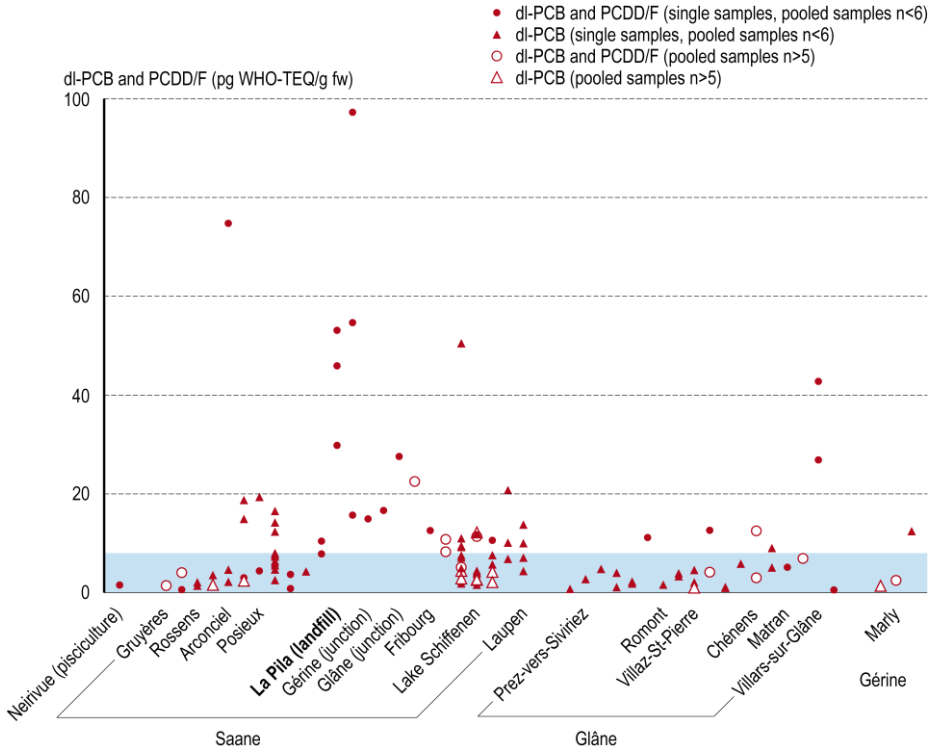
Methods: All available data on PCB and PCDD/F in fish and sediment from Swiss lakes and rivers were collected resulting in 1300 data sets from the last 20 years. The compilation was recently published by the Swiss Federal Office of the Environment in a final report[9].

Results and Discussion

On the basis of PCB levels in fish, the Swiss water bodies were classified into three categories. The first category was defined as water bodies with PCB background contamination corresponding to levels below 4 pg WHO-TEQ/g fw (50% of the maximum level of 8 pg WHO-TEQ/g fw). The second category containing water bodies with levels of 4 to 8 pg WHO-TEQ/g fw in fish was defined as water bodies with diffuse to higher PCB load. In these water bodies, older individuals or fat rich fish species already may exceed the maximum level of 8 pg WHO-TEQ/g fw. The third category was defined as water bodies with high PCB contamination. In water bodies of this category, most fish species clearly exceed the permitted maximum level. The highest PCB concentrations of up to 97 pg WHO-TEQ/g fw were found in fish from the river Saane downstream of the above mentioned landfill of La Pila. Similarly high PCB levels up to 60 pg WHO-TEQ/g fw were detected in various fish species from the rivers Birs and Rhine close to Basel. Up to now, the origins of the PCB contamination of the latter two rivers are not known.

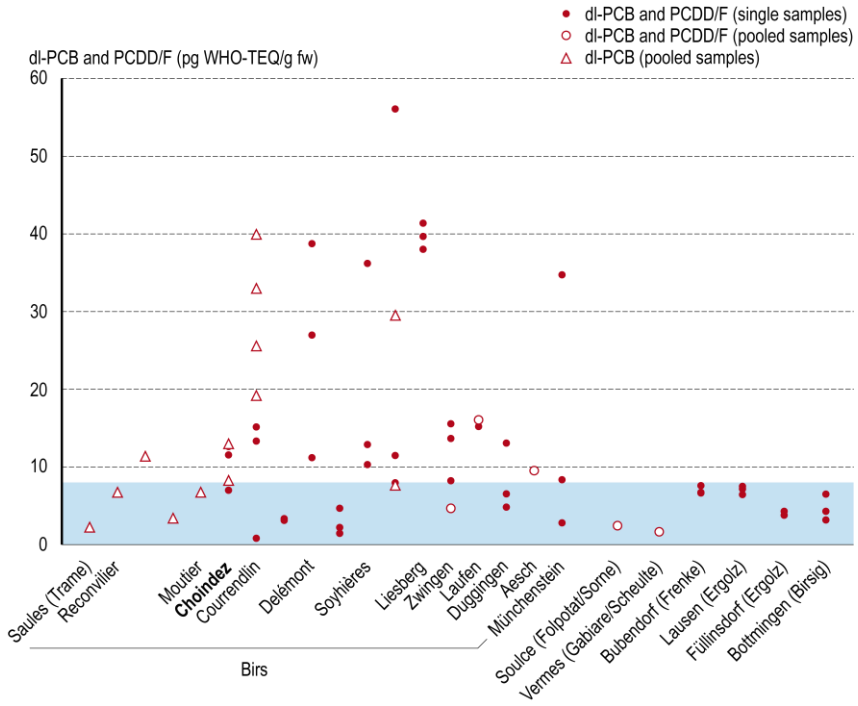
River Saane: Fig. 1 shows dl-PCB and PCDD/F levels in fish from the contaminated river Saane. The flow direction of the river is represented from left to right. Approximately 20% of over 120 single and pooled samples surpass the maximum level of 8 pg WHO-TEQ/g fw (shown as light blue range). In the section downstream of the landfill of La Pila to the city of Fribourg all samples exhibit dl-PCB concentrations above the permitted maximum level. Many of the analysed samples showing dl-PCB levels in the middle range are pooled samples composed of over 70 individuals. Therefore, some individuals of these sample pools are supposed to have very high dl-PCB levels, possibly in the range of the maximum level of 97 pg WHO-TEQ/g fw. In the samples where both dl-PCB and PCDD/F were determined, the average proportion of dl-PCB in the total WHO-TEQ content was 95 ± 5.4%. This clearly reflects the specific PCB contamination of the river.

Figure 1: dl-PCB and PCDD/F in fish from the river Saane and its catchment area including backwaters Glâne and Gérine.



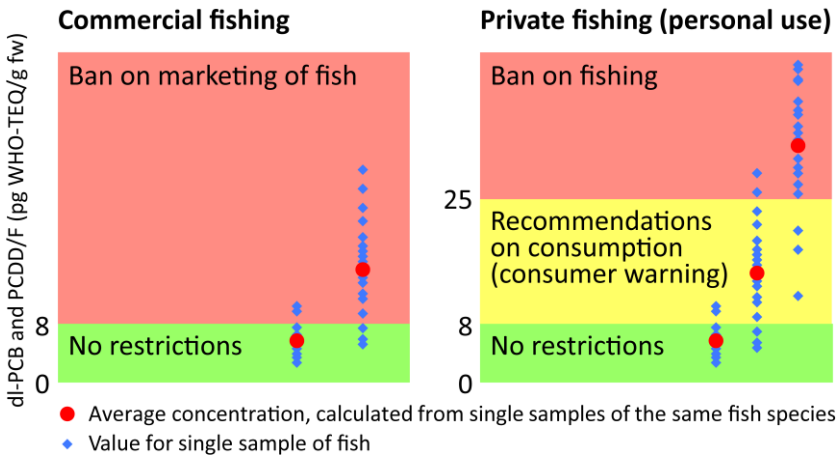
River Birs: Fig. 2 shows dl-PCB and PCDD/F levels in fish from the river Birs in Northwestern Switzerland measured in 2008 and 2009 in single and pooled samples of various fish species. The maximum level of 8 pg WHO-TEQ/g fw was clearly exceeded by almost 50% of the samples, most of them taken downstream of the barrage of Choindez. The highest measured value was 56 pg WHO-TEQ/g fw. In contrast, very low dl-PCB levels of 2.5 and 1.6 pg WHO-TEQ/g fw were found in fish from the headwaters of Sorne and Scheulte, respectively, two backwaters of the river Birs. The average proportion of PCDD/F of 6.7 ± 4.5% of the total WHO-TEQ was fairly low. Compared to the river Saane where the landfill of La Pila is responsible for the high PCB load, the PCB source in case of the river Birs is unknown so far. Therefore, a screening program was initiated in 2010 aimed at the identification of possible PCB point sources in the catchment of the river Birs. dl-PCB and PCDD/F will be measured in surface sediment samples taken along the river Birs to trace the contamination of the particle adsorbed load. Polydimethylsiloxane (PDMS) passive samplers[10] deployed at 15 locations for approximately four weeks shall help to determine the amount of PCB in the water phase.

Figure 2: dl-PCB and PCDD/F in fish from the river Birs in its catchment area.



Fish consumer protection: Since first of January 2009 the EU maximum levels for dl-PCB and PCDD/F in fish (8 pg WHO-TEQ/g fw and 12 pg WHO-TEQ/g fw for eel) are also valid in Switzerland. Nevertheless, no regulation or recommendation exists to protect recreational fishermen and their families from the exposure to PCB contaminated fish. Based on a TDI value of 10 pg WHO-TEQ/kg bw/day[11] the draft of fish contaminated with PCDD/F and dl-PCB above 25 pg WHO-TEQ/g fw has to be banned by the corresponding cantonal authorities. Fish containing between 8 and 25 pg WHO-TEQ/g fw can still be consumed by these fishermen and their relatives but the responsible authorities have to publish a consumer warning. The above mentioned procedure is illustrated in Fig. 3.

Figure 3: Recommended measures to reduce the PCB exposure of persons with constant consumption of fish.



Outlook: Most of the Swiss water bodies can be categorized as background contaminated with PCB. However, there are still some PCB hot spots present in Switzerland. Two of them are the rivers Saane and Birs. In order to complete the overview on the PCB contamination of the Swiss aquatic environment data gaps of several rivers and lakes should be closed in order to indentify and eliminate existing point sources. To this end, old landfills, former industrial production sites, and metal recycling plants (e.g. car and metal shredding) should be perused. Peculiar care has also to be taken in the demolition of buildings with suspected PCB legacies in building materials and electrical equipment. Furthermore, attention should be paid to dismantling, replacement, and recycling of steel constructions protected with PCB containing anti corrosion coatings. Especially in recycling or deposition of old electrical equipment PCB may still be released to the environment.
In case of the river Saane the PCB point source, the former landfill of La Pila, has been identified and more detailed investigations on this site are running. First remediation measures were taken to protect the environment from ongoing contamination with PCB and other chemicals released from the disposal site. For this purpose, the instable area of the landfill was stabilized. Waste with direct input into the river was excavated and deposited in the stable area of the landfill site until final disposal. Groundwater crossing the landfill site is collected, filtered, and released after control into the river. Major remediation works are planned for the years 2010 and 2011. The costs for the complete remediation of La Pila are estimated to be in the range of 10 to 20 million Swiss Francs. The case of the landfill of La Pila is but one of many, showing clearly that old sins may cast long shadows. Based on today's knowledge on classical and emerging persistent organic pollutants a proper handling and disposal of contaminated wastes should deserve top priority.

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